AME 3623: Embedded Real-Time Systems

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What is an Embedded System?
What is an Embedded System?

- Computing system with a non-standard interface (often no keyboard or screen)
- Often involved in sensing and control (and may not even talk to a human)
- Typically a custom system for a very specific application
What is an Embedded System? (cont)

• Limited processing capabilities:
  – Can be extremely small
  – Can require a small amount of power

• Can have significant real-time constraints
  – Act on inputs very quickly
  – Generate high-frequency outputs

• Often a higher expectation of reliability
Examples of Embedded Systems
Robotics

Mark Tilden
Los Alamos National Labs
and Wowwee

picture from Robosapiens

Humanoid Robotics

NASA/JSC Robonaut

UMass Torso
Real-Time Robotic Control
Dual-Limb Coordination
Personal Satellite Assistants

NASA Ames Research Center

picture from *Robosapiens*
Wearable Computing
Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

picture from *Robosapiens*
Embedded Systems Challenges
Embedded Systems Challenges

• Sensing the environment:
  – Sensors are typically far from ideal (noise, nonlinearities, etc.)
  – Sensors fail
  – Hard to get a ‘complete’ view of the environment

• Affecting the environment through “actuators”
  – Application can require fast, precise responses
Embedded Systems Challenges (cont)

- Testing/debugging can be very difficult:
  - Hard to identify and replicate all possible situations
  - Often involves the interaction of many different components
  - Often no standard user interface
  - Limited on-board resources with which to record system state

- Competing requirements of cost, complexity, design time, size, power...
Embedded Systems Challenges (cont)

• Lack of reliability can be a killer ..... literally
Course Goals

• Gain an understanding of:
  – Basics of computer architecture
  – Theory of embedded system design
  – Practical issues in embedded system implementation

• Gain hands-on experience with embedded systems

• Learn communication and team-oriented skills within and outside of your field
My Assumptions About You

• Circuits and sensors class (or equivalent): basic analog circuits

• Some background in programming
  – We will be using C for several projects

• Everyone has a laptop that can be used for the projects
Sources of Information

• Required textbooks:

• Class web page:  
  [www.cs.ou.edu/~fagg/classes/ame3623_s06/](http://www.cs.ou.edu/~fagg/classes/ame3623_s06/)

• Desire2Learn: learn.ou.edu

You are responsible for making sure that you have access to all of these resources
Class Schedule

www.cs.ou.edu/~fagg/classes/ame3623_s06/schedule.html

• Lecture plans
• Required reading

As changes are made, they will be posted here
Channels of Communication

• Lecture
• Class email list: time-critical messages to the class
• Desire2Learn announcements
• Desire2Learn discussion group: you may post questions (and answers)
• Private email or office hours for non-public questions/discussions
Grading

• Components of your grade:
  – Midterm exam: 10%
  – Final exam: 20%
  – Six homework assignments and several pop quizzes: 30%
  – Four projects: 35%
  – In-class participation: 5%

• Grades will be posted on the Desire2Learn

• Final grades will be computed on a curve
Exams

• Closed book/closed notes
  – Exception: you are allowed 1 page of your own notes

• Assigned seating

• No electronic devices

• Grading questions must be addressed before the returned exams leave the classroom
Homework Assignments

• Individual work

• Hand-in:
  – Through the digital dropbox of Desire2Learn or hardcopy
  – By 5:00 on the due date (no exceptions)

• Grading questions must be addressed within one week of being returned
Group Projects

• Four group projects will focus on sensor processing and design of robot control circuits
  – Robot will search for and follow a sequence of infrared beacons

• Project Topics:
  – Digital logic design
  – Finite-state machines and microcontrollers
  – Sensor processing
  – Inter-processor communication

www.lynxmotion.com
Group Projects (cont)

• Groups will be of size ~4 and will be assigned
• Be ready to demonstrate project by the due date
• Projects require more than a day to complete
• Project reports in pdf or postscript format
• Projects may be late:
  – 0-24 hrs: 10% penalty
  – 24-48 hrs: 20% penalty
  – 48+ hrs: 100% penalty
Laboratory Details

• Location: EL 124

• Times: both myself and the TA will hold our office hours in the lab
  – Once projects are assigned, we will have the lab open for 18 hrs/week

• Laboratory policies are discussed in the syllabus
Academic Conduct/Misconduct

Homework assignments:

• All work must be your own: no looking at or copying solutions from other students or from the net

• General discussion is OK (e.g., the fundamental skills that we are learning)

• When in doubt: ask
Academic Conduct/Misconduct

Projects:
• All work must be that of your group: no looking at or copying solutions from other groups or from the net
• General discussion is (again) OK

Secure your data
Reading for Today

• Embedded Systems Architecture (ESA) Chapter 1
Next Time

• Introduction to digital logic and Boolean Algebra
• Readings:
  – ESA 3.1, 3.4, 3.5.1, 3.6 (not flip-flops)
  – Web pages on basic gates and Boolean algebra
“Bion:” An Experiment in Sensor Networks and Art

- New York Sculptor’s Guild 60th Anniversary Retrospective
- Hillwood Museum, Long Island University
- Jan 30th – April 8th